

ARC-15042-2

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Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: Hou Te Ng et al

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U.S. Serial No: 10/816,576

Group Art Unit: 2813

Filed On: 24 March 2004

Examiner: Thanh T. Nguyen

Title: "METALLIC NANOWIRE INTERCONNECTIONS
FOR INTEGRATED CIRCUIT FABRICATION"

Assistant Commissioner for Patents

P.O. Box 1450

Alexandria, Virginia. 22313-1450

AMENDMENT AND RESPONSE (FINAL REJECTION)

Dear Sir:

In response to receipt of an Office Action, mailed 06 April 2006, for the patent application identified above, please enter the following amendments.

Pages 2-4 set forth the claims, as amended

Pages 6-8 set forth a Reply To Examiner's Remarks.

In the claims:

All pending claims are set forth here. Cancel claim 15. Amend claim 1 to read as follows.

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1 (currently amended). A method for fabricating an electrical connection, the method comprising:

~~providing an electrically non-conductive layer of a first selected material, having a first selected thickness, on an exposed surface of a substrate of selected substrate material;~~

providing an electrically conductive layer of a second selected material, having a second selected thickness, in a first selected pattern having at least first and second spaced apart conductive layer components, on an exposed surface of the non-conductive layer;

depositing a catalyst array, including at least first and second spaced apart catalyst array elements, of metallic nanowire ("MeNW") catalyst material of a selected catalyst thickness on the respective first and second conductive layer components;

providing a gas or vapor of a selected metallic ~~or organometallic~~ material around the catalyst array, and allowing at least first and second MeNWs to grow, substantially perpendicular to a plane Π of the conductive layer on the respective first and second conductive layer components;

providing a diffusion barrier of a selected barrier material as a thin coating surrounding a side wall of the at least two MeNWs and overlying exposed portions of the conductive layer, to prevent migration of the ~~MeNW~~ conductive layer material;

depositing an insulation layer of a selected insulation material over the exposed portions of the conductive layer and around the at least two MeNWs so that an interstitial region between the at least two MeNWs contains the insulation material; and

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applying a chemical mechanical polishing process ~~or etching process~~ to remove a fraction of each of the at least two MeNWs, and a fraction of the insulation layer so that each of the at least two MeNWs has an end exposed.

2 (original). The method of claim 1, further comprising applying an electrical field **E1**, substantially perpendicular to said plane Π , as said at least one MeNW is grown.

3 (original). The method of claim 1, further comprising applying an electrical field **E2**, substantially parallel to said plane Π , as said at least one MeNW is grown.

4 (canceled).

5 (previously amended). The method of claim 1, further comprising selecting said diffusion barrier material from the materials Ti_xN_y and Ta_xN_y , where x and y are positive numbers.

6 (canceled).

7 (previously amended). The method of claim 1, further comprising selecting said diffusion barrier material from the materials Ti_xN_y and Ta_xN_y , where x and y are positive numbers.

8 (original). The method of claim 1, further comprising selecting said conductive layer material from a group of materials that includes Cu, Ag, Au, Pt, Pd, Ni, Fe, Co, Ir, Ti, Zr and a metal-doped silicide

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9 (original). The method of claim 1, further comprising selecting said catalyst layer material from a group of materials that includes Al, Au, Ag, Ni, Ir, Mo, Pt and Pd.

10 (original). The method of claim 1, further comprising selecting said metallic material for said at least two MeNWs from a group of materials that includes Cu, Cu_xO_y , Al, Al_wCu_z , Ag, Au, Pt and Pd, where w, x, y and z are positive numbers.

11 (original). The method of claim 1, further comprising selecting said insulation material from a group of materials that includes Si, Si_aO_b and Si_cN_d , where a, b, c and d are selected positive numbers.

12 (original). The method of claim 1, further comprising selecting said thickness of said catalyst layer in a range 0.1 – 20 nanometers.

13 (previously amended). The method of claim 1, further comprising selecting said thickness of said conductive layer in a range 0.2 – 250 nm..

14 (original). The method of claim 1, further comprising providing at least one of said at least two MeNWs with a diameter, measured in a plane substantially parallel to said plane Π , in a range 1 – 250 nm.

15 (canceled).

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16 (new). The method of claim 1, further comprising choosing said diffusion barrier material to be an electrically conductive material.

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Reply To Examiner's Remarks

Claims 1-3, 5, 7-14 and 16, as amended, are presented for consideration.

The Examiner rejects claims 1-3, 5, 7-16 under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement, noting that the recited claims clauses "non-electrically conductive layer," "organometallic," "etching process," in claim 1, and "non-conductive material" in claim 15 are not described in the original specification. These claims clauses are deleted herein.

The Examiner also asserts that the claims clause "to prevent migration of the MeNW material" in claim 1 does not appear in the original specification. Use of a diffusion barrier 23 (e.g., of TiN or TaN) to prevent metal diffusion of the underlying conductive layer material to adjacent material, is discussed at page 5, lines 9-13, claims 1, 6 and 7 of the original specification, and Figure 1A, step 12. Claim 1 is amended to recite

"providing a diffusion barrier of a selected barrier material as a thin coating surrounding a side wall of the at least two MeNWs and overlying exposed portions of the conductive layer, to prevent migration of the conductive layer material;"

The Examiner rejects claims 1-3, 5, 7-14 and 16 under 35 U.S.C. 102 as anticipated by the disclosures in published U.S. patent application no. 2003/0189202, filed by Li et al (the "Li PPA"), published patent application no. 2001/0030366, filed by Nakano et al (the "Nakano et al PPA"), and published patent application no. 2004/0071951, filed by in (the "Jin PPA"), referred to collectively herein as "the cited references."

The Li et al PPA discloses methods for fabrication of nanowire devices in which: (1) one or more electrodes is set down on a conducting substrate; (2) a pattern of one or more nanowire growth catalyst sites is provided on each

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electrode; (3) one or more nanowires is grown on each catalyst site; (4) each nanowire is connected to a selected electrical source at an “exposed end” of the nanowire; (5) each nanowire is surrounded by interstitial electrical insulation, extending between adjacent nanowires, to insulate the nanowires from each other; (6) each nanowire is planarized at an exposed end to expose a tip of a nanowire above the insulation material (Figures 4a-4f). The Li et al PPA does not disclose or suggest

“providing a diffusion barrier of a selected barrier material as a thin coating surrounding a side wall of the at least two MeNWs and overlying exposed portions of the conductive layer, to prevent migration of the MeNW material”

as recited in claim 1 of the subject patent application.

The Jin PPA discloses a high density information storage medium and fabrication method, which uses a periodic array of vertically aligned carbon nanotubes (“CNTs”) for such storage. Each CNT is coated with, or filled with, a selected magnetic material (Fe, Ni, Co), interstitial gaps between adjacent coated CNTs are filled with a non-magnetic material, such as a metal or alloy (Al, Ti, Si, Cu, Mo or Cr or alloy thereof) and the array of coated CNTs and gap material are planarized to expose tips of the coated or filled CNTs (Figure 3). Optionally, as indicated in Figures 5B and 5C, the nanowire surfaces are oxidized, and subsequently subjected to a reducing atmosphere. Figures 5(a), 5(b) and 5(c) of the Jin et al PPA, and paragraphs 0044, 0045 and 0046 of the published specification, disclose that the nanowires 12 (used for high density recording according to the PPA) are provided with an oxidized surface 50, by heating in a high temperature, oxygen-rich environment. According to paragraph 0045, this oxidized surface serves to decrease the diameter of the magnetic core – but no other purpose for provision of the oxidized surface is given.

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The Nakano PPA discloses a method for producing a semiconducting system, using a protective coating of TaN or TiN. Paragraph 0012 of the Nakano et al PPA notes that SiN is insulating and has been used as a wire protective film, with a high specific dielectric constant. The paragraph also notes that nitrides such as Ti_xN_y , Ta_xN_y and W_xN_y have been used as a high melt point wire protective film and to avoid short circuiting between wires. No other purpose for provision of the wire protective film is given in the Nakano et al PPA.

Claim 1, as amended, and the discussion in the specification of the subject patent application, recite that a diffusion barrier of a selected barrier material as a thin coating surrounding a side wall of the at least two MeNWs and overlying exposed portions of the conductive layer is provided, to prevent migration of the conductive layer material into adjacent material. Material chosen as a wire protective film or to decrease a diameter of a magnetic core for a memory element, would not necessarily behave properly as a diffusion barrier, and conversely. Thus, it would not have been obvious to provide a diffusion barrier, for the purpose recited in amended claim 1, from the relevant portions of the disclosures in the Li et al PPA, the Jin et al PPA and/or the Nakano et al PPA.

The Applicants believe that claim 1, as amended, of the subject patent application is allowable over the disclosures in the cited references. Claims 3-5, 7-14 and 16, as amended, depend upon amended claim 1 and are believed to be allowable if amended claim 1 is allowable. The Applicants request that the Examiner pass the application, including claims 1, 3-5, 7-14 and 16, as amended, to issue as a U.S. patent.

Respectfully Submitted,



John Schipper

Date: 06 October 2006

Patent representative for Applicants

Reg. No. 26994

PTO/SB/30 (04-05)

Approved for use through 07/31/2008. OMB 0651-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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Request for Continued Examination (RCE) Transmittal

Address to:
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Alexandria, VA 22313-1450

Application Number	10/816,576
Filing Date	24 March 2004
First Named Inventor	Hou Te Ng
Art Unit	2813
Examiner Name	Thanh T. Nguyen
Attorney Docket Number	ARC-15042-2

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This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application. Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. **Submission required under 37 CFR 1.114** Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

- a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.
- i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ii. ☐ Other _____
- b. ☒ Enclosed
- i. ☒ Amendment/Reply
- iii. ☐ Information Disclosure Statement (IDS)
- ii. ☐ Affidavit(s)/ Declaration(s)
- iv. ☒ Other Facsimile Transmission Certificate (1 pg)

2. Miscellaneous

- a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)
- b. ☐ Other _____

3. Fees

- The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.
- The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 14-0118. I have enclosed a duplicate copy of this sheet.
- i. ☒ RCE fee required under 37 CFR 1.17(e) \$790.00
- ii. ☒ Extension of time fee (37 CFR 1.136 and 1.17) \$1020.00 - Petition to Extend Time for Reply Attached (1pg)
- iii. ☐ Other _____
- b. ☐ Check in the amount of \$ _____ enclosed
- c. ☐ Payment by credit card (Form PTO-2038 enclosed)

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SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	<i>John F. Schipper</i>	Date	06 October 2006
Name (Print/Type)	John F. Schipper	Registration No.	26,994

CERTIFICATE OF MAILING OR TRANSMISSION

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Signature	<i>John F. Schipper</i>	Date	06 October 2006
Name (Print/Type)	John F. Schipper		

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2005 <small>(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4618).)</small>		Docket Number (Optional) ARC-15042-2	
Application Number 10/816,576		Filed 24 March 2004	
For Metallic Nanowire Interconnections For Integrated Circuit Fabrication		OCT 06 2006	
Art Unit 2813		Examiner Thanh T. Nguyen	

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	<u>Fee</u>	<u>Small Entity Fee</u>	
<input type="checkbox"/> One month (37 CFR 1.17(a)(1))	\$120	\$80	\$ _____
<input type="checkbox"/> Two months (37 CFR 1.17(a)(2))	\$450	\$225	\$ _____
<input checked="" type="checkbox"/> Three months (37 CFR 1.17(a)(3))	\$1020	\$510	\$ <u>1020.00</u>
<input type="checkbox"/> Four months (37 CFR 1.17(a)(4))	\$1590	\$795	\$ _____
<input type="checkbox"/> Five months (37 CFR 1.17(a)(5))	\$2160	\$1080	\$ _____

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 14-0116 I have enclosed a duplicate copy of this sheet.

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I am the ☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☒ attorney or agent of record. Registration Number 26,994

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 _____

John F. Schipper
Signature

John F. Schipper
Typed or printed name

06 October 2006
Date

(650) 604-0887
Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☐ Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Appl. No.: 10/816,576	Examiner: Thanh T. Nguyen
Applicant: Hou Te Ng, et al.	Docket No.: ARC-15042-2
Filed: 24 March 2006	Customer No.: 25186
TC/A.U.: 2813	Confirmation No. 9400

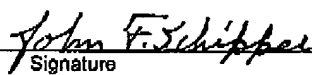
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- Petition to Extend Time for Reply (1 page, in duplicate)
- Amendment (8 pages)

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